

Federal Aviation Administration – [Regulations and Policies](#)
Aviation Rulemaking Advisory Committee

Transport Airplane and Engine Issue Area
General Structures Harmonization Working Group

Task 8 – Casting Factor

Task Assignment

[Federal Register: September 18, 1998 (Volume 63, Number 181)]
[Notices]
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DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Aviation Rulemaking Advisory Committee; Transport Airplane and
Engine Issues, New Tasks

AGENCY: Federal Aviation Administration (**FAA**), DOT.

ACTION: Notice of new task assignments for the Aviation Rulemaking
Advisory Committee (ARAC).

SUMMARY: Notice is given of new tasks assigned to and accepted by the
Aviation Rulemaking Advisory Committee (ARAC). This notice informs the
public of the activities of ARAC.

FOR FURTHER INFORMATION CONTACT: Stewart R. Miller, Transport Standards
Staff (ANM-110), Federal Aviation Administration, 1601 Lind Avenue,
SW., Renton, WA 98055-4056; phone (425) 227-1255; fax (425) 227-1320.

SUPPLEMENTARY INFORMATION:

Background

The **FAA** has established an Aviation Rulemaking Advisory Committee
to provide advice and recommendations to the **FAA** Administrator, through
the Associate Administrator for Regulation and Certification, on the
full range of the **FAA**'s rulemaking activities with respect to aviation-
related issues. This includes obtaining advice and recommendations on
the **FAA**'s commitment to harmonize its Federal Aviation Regulations
(FAR) and practices with its trading partners in Europe and Canada.

One area ARAC deals with is Transport Airplane and Engine Issues.
These issues involve the airworthiness standards for transport category
airplanes and engines in 14 CFR parts 25, 33, and 35 and parallel
provisions in 14 CFR parts 121 and 135.

The Tasks

This notice is to inform the public that the **FAA** has asked ARAC to
provide advice and recommendation on the following harmonization tasks.

Task 8: Casting Factors

Review the current standards of Sec. 25.621 and those proposed for
the corresponding JAR 25.621 in NPA 25C-272 (circulated for public
consultation by JAA on 16 November 1997) as they pertain to the

strength of structural castings. Review also any available **FAA** and JAA advisory material. In the light of this review, recommend changes to harmonize this section and the corresponding JAR paragraph, recommend new harmonized standards, and develop related advisory material as necessary.

The **FAA** expects ARAC to submit its recommendation(s) resulting from this task by July 31, 2001.

Task 9: Fuel Tank Access Doors

Review the current standards of FAR 25.963(e) and JAR 25.963(g) as they pertain to the requirements for fuel tank access doors impact and fire resistance. Review also the related **FAA** and JAA advisory material. In the light of this review, recommend changes to harmonize these sections and the corresponding JAR paragraphs, recommend new harmonized standards, and develop related advisory material as necessary.

The **FAA** expects ARAC to submit its recommendation(s) resulting from this task by July 31, 2001.

Task 10: Strength of Windshields and Windows

Review the current standards of Sec. 25.775 and those for corresponding JAR 25.775 as they pertain to the strength of windshields and windows. Review also any related **FAA** and JAA advisory material. In the light of this review, recommend changes to harmonize this section and the corresponding JAR paragraph, recommend new harmonized standards, and develop related advisory material as necessary.

The **FAA** expects ARAC to submit its recommendation(s) resulting from this task by March 31, 2001.

The **FAA** requests that ARAC draft appropriate regulatory documents with supporting economic and other required analyses, and any other related guidance material or collateral documents to support its recommendations. If the resulting recommendation(s) are one or more notices of proposed rulemaking (NPRM) published by the **FAA**, the **FAA** may ask ARAC to recommend disposition of any substantive comments the **FAA** receives.

Working Group Activity

The General Structures Harmonization Working Group is expected to comply with the procedures adopted by ARAC. As part of the procedures, the working group is expected to:

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1. Recommend a work plan for completion of the tasks, including the rationale supporting such a plan, for consideration at the meeting of ARAC to consider transport airplane and engine issues held following publication of this notice.

2. Give a detailed conceptual presentation of the proposed recommendations, prior to proceeding with the work stated in item 3 below.

3. Draft appropriate regulatory documents with supporting economic and other required analyses, and/or any other related guidance material or collateral documents the working group determines to be appropriate; or, if new or revised requirements or compliance methods are not recommended, a draft report stating the rationale for not making such

recommendations. If the resulting recommendation is one or more notices of proposed rulemaking (NPRM) published by the **FAA**, the **FAA** may ask ARAC to recommend disposition of any substantive comments the **FAA** receives.

4. Provide a status report at each meeting of ARAC held to consider transport airplane and engine issues.

The Secretary of Transportation has determined that the formation and use of ARAC are necessary and in the public interest in connection with the performance of duties imposed on the **FAA** by law.

Meetings of ARAC will be open to the public. Meetings of the General Structures Harmonization Working Group will not be open to the public, except to the extent that individuals with an interest and expertise are selected to participate. No public announcement of working group meetings will be made.

Issued in Washington, DC, on September 14, 1998.
Joseph A. Hawkins,
Executive Director, Aviation Rulemaking Advisory Committee.
[FR Doc. 98-25070 Filed 9-17-98; 8:45 am]
BILLING CODE 4910-13-M

Recommendation Letter



July 27, 1999

Department of Transportation
Federal Aviation Administration
800 Independence Ave. S.W.
Washington, D.C. 20591

Attn: Ms. Brenda Courtney, Acting Director – Office of Rulemaking

Dear Ms. Courtney:


The Transport Airplane and Engine Issues Group is pleased to provide the attached draft NPRM and AC for harmonization of FAR/JAR 25.621, Casting Factors to the FAA for formal legal and economic review. This draft NPRM and AC has been prepared by the General Structures Harmonization Working Group.

In summary, the rule change adds rule provisions allowing the use of a casting factor of 1.0 under certain conditions. The conditions are delineated in the rule and are further explained in the advisory material. The text of the rule has also been rearranged for clarification and ease of understanding. A new AC has been drafted, and it primarily addresses means of compliance for use of casting factor of 1.0, although some general rule advisory material is included.

The Structures Harmonization Working Group, with representatives from U.S., European and Canadian industry, the FAA, JAA and Transport Canada, examined the draft NPRM and draft AC for 25.621 to evaluate the cost impact for compliance relative to the existing regulatory material. The following is provided to assist the FAA economist in evaluation of this material.

1. Casting technology has made significant progress since the existing 25.621 rule was adopted. Today, much higher quality castings can be produced using improved foundry methods. For some time, the aircraft industry has needed a rule change to allow use of the technology to obtain lighter weight, lower cost parts. The new provision of the rule allowing use of a casting factor of 1.0 is not mandatory, but rather allows the applicant to select an alternative factor relative to applicable factors today. Therefore, the rule change is relieving and may in fact result in cost reductions.

2. The current JAR does not specify casting factors, but allows the use of the national rules of the JAA member countries. By adopting this harmonized material, the certification process and related costs will be improved for industry and authorities alike.



Craig R. Bolt
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CRB/amr

Attachment

cc: Dorenda Baker – FAA-ANM
Kristin Larson – FAA-ANM
Amos Hoggard - Boeing

Recommendation

[4910-13]

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 25

Docket No. ; **Notice No.**]

RIN 2120-

[Title] Casting Factors

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of proposed rulemaking (NPRM).

SUMMARY: This notice proposes to amend the casting factors requirements of §25.621 to permit the use of a casting factor of 1.0 for critical castings. For critical castings, the current regulation requires a minimum factor of 1.25, to be applied in addition to the factor required by §25.303. This proposal also would relieve manufacturers of the burden of dual certification by harmonizing the Federal Aviation Regulations (FAR) with the European Joint Aviation Requirements (JAR) and would eliminate differences in interpretation of rules by providing a companion advisory circular(AC).

DATES: Comments must be received on or before

ADDRESSES:

Comments on this document should be mailed or delivered, in duplicate, to: U.S.

Department of Transportation Dockets, Docket No. [], 400 Seventh Street SW.,

Room Plaza 401, Washington, DC 20590. Comments also may be sent electronically to the following Internet address: 9-NPRM-CMTS@faa.gov. Comments may be filed and

examined in Room Plaza 401 between 10 a.m. and 5 p.m. weekdays, except Federal holidays.

FOR FURTHER INFORMATION CONTACT: William M. Perrella, Federal Aviation Administration. 1605 Lind Ave SW, Renton, Washington, 98056; telephone 425 227-2116; facsimile 425-227-1100.

SUPPLEMENTARY INFORMATION:

Background: The current 14 CFR part 25 Airworthiness Standards of the Federal Aviation Regulations (FAR) requires classification of structural castings as either critical or non-critical, and depending on classification, specifies inspection requirements, test requirements, and special factors for ultimate strength and deformation.

The requirements specified in §25.621 have been in effect for many years, having been carried forward from CAR 4b.307. Prior to that, Civil Aeronautics Manual 04 required a minimum additional ultimate strength factor of 2.0 for castings used in primary structure. The Administrator had the authority to prevent the use of any casting which was not considered acceptable for a given application.

In recent years, casting technology has improved. The use of casting factors for critical applications often results in enough of a weight penalty that other, more expensive processes are necessary.

The European Joint Aviation Requirements (JAR) accept the approved national standards of the participants as an alternative to FAR §25.621. The JAA also have a Notice of Proposed Amendment in process to add a new JAR 25.621, and to include provision for the use of a casting factor of 1.0. Because of the differences in the FAA and JAA requirements and the economic costs associated with those differences, the ARAC

General Structures Harmonization Working Group was tasked by the FAA to develop a common requirement. Part of the assigned task was to consider making provision in the rule to allow use of a casting factor of 1.0 for critical castings.

Discussion: Castings are subject to variability in mechanical properties due to the casting process, which can result in imperfections, such as voids, within the cast part. Using certain inspection techniques, for example X-ray, it is possible to detect such imperfections above a minimum detectable size which depends on the dimensions of the part, the inspection equipment used, and the skill of the inspector. Because of the uncertainties in both the casting process and the inspection process, a minimum casting factor of 1.25 is currently specified for critical castings. Associated with use of this casting factor are static tests and inspection requirements.

If tight controls are established on the casting process, it is possible to produce castings with variability of mechanical properties similar to those of wrought alloys. These castings, which are of high quality and reliability, are sometimes called “premium castings”.

While the requirement for casting factors had long been in effect, in 1978 the fail-safe requirement of §25.571 was replaced by a damage tolerant requirement (amendment 25-45). Prior to amendment 25-45, the fail-safe features of the design were considered when deciding whether to classify a casting as critical or non-critical. For example, if two castings were used to perform a single function, and each had the ability to carry fail-safe loads, each casting could be considered non-critical. Under damage tolerance, multiple damage must be considered. A casting which is a PSE as defined in AC 25.571-1C or part of a PSE, the failure of which could preclude continued safe flight and landing,

must be classified as a critical casting. It is therefore proposed to revise the first sentence of section 25.621(c) by replacing the word "would" with the word "could".

During discussions by the working group, there was a question of whether a casting factor should be applied to residual strength loads, if such a factor were being applied to the ultimate load case for the undamaged part. The working group concluded that there was no justification or need to apply a factor to the residual strength loads of §25.571, since the factor was already being applied to the undamaged part, to account for uncertainties in material properties and inspection techniques. In fact, that is how the requirement has traditionally been interpreted and applied by FAA.

In addition, this proposal would permit the use of a casting factor of 1.0 for critical castings provided tight controls are established for the casting process, inspection, testing, and that material strength properties have no more variability than equivalent wrought alloys.

The working group concluded that each critical casting must receive visual and special nondestructive inspections, as required by the existing requirement, and any flaws smaller than detectable would not reduce the properties of the casting below that for which certification is shown. However, for large parts, not all areas of which may be sensitive to certain flaw types, the special nondestructive inspections could be limited to specified areas of the casting. This is provided that visual inspections would be capable of detecting the specified flaws for which certification is demonstrated. Static tests would still be required for a casting factor of 1.0; however, only one sample would be tested. This is because the material variability of such castings is similar to that of wrought alloys. The qualification program would have to ensure that the casting method

is able to produce a consistent product, with uniform properties throughout the casting. To help assure quality, test castings from several melts, using foundry production procedures, would be inspected, cut up and inspected, metallographically examined, and tested for mechanical properties. The companion advisory circular to this NPRM describes in detail a means for satisfying the requirements associated with the use of a casting factor of 1.0.

The use of a casting factor of 1.0 for critical castings would eliminate the weight penalty of the current requirement and enable less costly castings to be used in place of forgings, assembled structure, or machined parts.

Although the proposed rule covers a range of casting factors greater than one, it is anticipated that applicants will actually use the lower value of each band (1.0, 1.25, 1.50, 2.0).

The proposed 25.621(c) would require that for critical castings with a casting factor of greater than 1.5 one specimen needs to be statically tested. This is not required in the existing rule. The proposed requirement was added to assure the same confidence level in addressing material variability for critical castings for different possible casting factors.

Minor editorial changes were also made to paragraphs (a) and (d).

Comments Invited

Interested persons are invited to participate in the making of the proposed action by submitting such written data, views, or arguments as they may desire. Comments relating to the environmental, energy, federalism, or economic impact that might result from adopting the proposals in this document also are invited. Substantive comments

should be accompanied by cost estimates. Comments must identify the regulatory docket or notice number and be submitted in duplicate to the DOT Rules Docket address specified above.

All comments received, as well as a report summarizing each substantive public contact with FAA personnel concerning this proposed rulemaking, will be filed in the docket. The docket is available for public inspection before and after the comment closing date.

All comments received on or before the closing date will be considered by the Administrator before taking action on this proposed rulemaking. Comments filed late will be considered as far as possible without incurring expense or delay. The proposals in this document may be changed in light of the comments received.

Commenters wishing the FAA to acknowledge receipt of their comments submitted in response to this document must include a pre-addressed, stamped postcard with those comments on which the following statement is made: "Comments to Docket No. _____." The postcard will be date stamped and mailed to the commenter.

Availability of NPRMs

An electronic copy of this document may be downloaded using a modem and suitable communications software from the FAA regulations section of the FedWorld electronic bulletin board service (telephone: (703) 321-3339), the Government Printing Office (GPO)'s electronic bulletin board service (telephone: (202) 512-1661), or, if applicable, the FAA's Aviation Rulemaking Advisory Committee bulletin board service (telephone: (800) 322-2722 or (202) 267-5948).

Internet users may reach the FAA's web page at <http://www.faa.gov/avr/arm/nprm/nprm.htm> or the GPO's web page at <http://www.access.gpo.gov/nara> access to recently published rulemaking documents.

Any person may obtain a copy of this document by submitting a request to the Federal Aviation Administration, Office of Rulemaking, ARM-1, 800 Independence Avenue SW., Washington, DC 20591, or by calling (202) 267-9680. Communications must identify the notice number or docket number of this NPRM.

Persons interested in being placed on the mailing list for future rulemaking documents should request from the above office a copy of Advisory Circular No. 11-2A, Notice of Proposed Rulemaking Distribution System, which describes the application procedure

Paperwork Reduction Act

In accordance with the Paperwork Reduction Act of 1995 (44 U.S.C. 3507(d)), the FAA has determined that there are no requirements for information collection associated with this proposed rule.

Compatibility With ICAO Standards

In keeping with U.S. obligations under the Convention on International Civil Aviation, it is FAA policy to comply with International Civil Aviation Organization (ICAO) Standards and Recommended Practices to the maximum extent practicable. The FAA has reviewed the corresponding ICAO Standards and Recommended Practices and has identified no differences with these proposed regulations.

Regulatory Evaluation Summary

Changes to Federal regulations must undergo several economic analyses. First, Executive Order 12866 directs that each Federal agency shall propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs. Second, the Regulatory Flexibility Act of 1980 requires agencies to analyze the economic effect of regulatory changes on small entities. Third, OMB directs agencies to assess the effect of regulatory changes on international trade. In conducting these analyses, the FAA has determined this proposed rule is not "a significant regulatory action" under section 3(f) of Executive Order 12866 and, therefore, is not subject to review by the Office of Management and Budget. This proposed rule is not considered significant under the regulatory policies and procedures of the Department of Transportation (44 FR 11034, February 26, 1979). This proposed rule would not have a significant impact on a substantial number of small entities and would not constitute a barrier to international trade. The FAA invites the public to provide comments and supporting data on the assumptions made in this evaluation. All comments received will be considered in the final regulatory evaluation.

[Insert summary of the economic evaluation prepared by APO.]

Initial Regulatory Flexibility Determination

The Regulatory Flexibility Act (RFA) of 1980, 5 U.S.C. 601–612, was enacted by U.S. Congress to ensure that small entities are not unnecessarily or disproportionately burdened by Government regulations. The RFA requires a regulatory flexibility analysis if a proposed rule has a significant economic impact on a substantial number of small business entities. FAA Order 2100.14A, Regulatory Flexibility Criteria and Guidance, establishes threshold costs and small entity size standards for complying with RFA requirements.

[Insert summary of the regulatory flexibility finding prepared by APO.]

International Trade Impact Statement

The provisions of this proposed rule would have little or no impact on trade for U.S. firms doing business in foreign countries and foreign firms doing business in the United States.

Federalism Implications

The regulations proposed herein would not have a substantial direct effect on the States, on the relationship between the national Government and the States, or on the distribution of power and responsibilities among the various levels of government. Therefore, in accordance with Executive Order 12612, it is determined that this proposal would not have sufficient federalism implications to warrant the preparation of a federalism assessment.

Unfunded Mandates Reform Act

Title II of the Unfunded Mandates Reform Act of 1995 (the Act), codified in 2 U.S.C. 1501—1571, requires each Federal agency, to the extent permitted by law, to

prepare a written assessment of the effects of any Federal mandate in a proposed or final agency rule that may result in the expenditure by State, local, and tribal governments, in the aggregate, or by the private sector, of \$100 million or more (adjusted annually for inflation) in any one year. Section 204(a) of the Act, 2 U.S.C. 1534(a), requires the Federal agency to develop an effective process to permit timely input by elected officers (or their designees) of State, local, and tribal governments on a proposed "significant intergovernmental mandate." A "significant intergovernmental mandate" under the Act is any provision in a Federal agency regulation that would impose an enforceable duty upon State, local, and tribal governments, in the aggregate, of \$100 million (adjusted annually for inflation) in any one year. Section 203 of the Act, 2 U.S.C. 1533, which supplements section 204(a), provides that before establishing any regulatory requirements that might significantly or uniquely affect small governments, the agency shall have developed a plan that, among other things, provides for notice to potentially affected small governments, if any, and for a meaningful and timely opportunity to provide input in the development of regulatory proposals.

This proposed rule does not contain a Federal intergovernmental or private sector mandate that exceeds \$100 million in any one year.

Environmental Analysis

FAA Order 1050.1D defines FAA actions that may be categorically excluded from preparation of a National Environmental Policy Act (NEPA) environmental assessment or environmental impact statement. In accordance with FAA Order 1050.1D, appendix 4, paragraph 4(j), regulations, standards, and exemptions (excluding those, which if implemented may cause a significant impact on the human environment) qualify for a categorical exclusion. The FAA proposes that this rule qualifies for a categorical exclusion because no significant impacts to the environment are expected to result from its finalization or implementation.

Energy Impact *The OPI is responsible for assessing the energy impact of a proposed rule. State whether the energy impact of the proposed rule has been assessed in accordance with the Energy Policy and Conservation Act (EPCA) and Public Law 94–163, as amended (42 U.S.C. 6362). Also state whether it has been determined that it is not a major regulatory action under the provisions of the EPCA. AEE currently is drafting standard language for this statement.*

List of Subjects in 14 CFR Part 25

List of Subjects *List the parts in numerical order.*

14 CFR Part 25

Insert appropriate index terms.

14 CFR Part 25

Insert appropriate index terms.

The Proposed Amendment

In consideration of the foregoing, the Federal Aviation Administration proposes to amend part 25 of Title 14, Code of Federal Regulations as follows:

PART 25—AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES

1. The authority citation for part 25 to read as follows:

Authority: 49 U.S.C.[]

Amend §25.621 to read as follows:

§ 25.621 Casting factors.

(a) *General.* For castings used in structural applications the factors, tests, and inspections specified in paragraphs (b) through (d) of this section must be applied in addition to those necessary to establish foundry quality control. The inspections must meet approved specifications. Paragraphs (c) and (d) of this section apply to any structural castings except castings that are pressure tested as parts of hydraulic or other fluid systems and do not support structural loads.

(b) * * * *

(c) *Critical castings.* Each casting whose failure could preclude continued safe flight and landing of the airplane or result in serious injury to occupants is considered to be a critical casting. Examples of castings which may be critical are structural attachment fittings, parts of flight control systems, control surface hinges and balance weight attachments, seat, berth, safety belt, fuel and oil tank supports and attachments, pressurized doors, and cabin pressure valves. Each critical casting must have a factor associated with it for showing compliance with strength and deformation requirements and comply with the following criteria associated with that factor:

- 1) A Casting Factor of greater than or equal to 1.0 and less than 1.25 may be used provided that:
 - i. Castings are procured and manufactured to specifications that guarantee the mechanical properties of the material in the casting considering environmental

effects, variability and also provides for demonstration of these properties by testing of coupons cut from the castings on a routine basis. There must be demonstration in the form of process qualification, proof of product, and process monitoring that for each casting design the castings produced by each foundry, and process combination consistently meet the required specifications. The coefficients of variation of the casting material properties must be equivalent to those of wrought products of similar composition.

- ii. Each casting must receive 100 percent inspection by visual, radiographic, and liquid penetrant methods or approved equivalent nondestructive inspection methods.
- iii. One casting must be statically tested and shown to meet the strength and deformation requirements of § 25.305.

2) Casting Factors of greater than or equal to 1.25 and less than 1.50 may be used provided that:

- i. Each casting must receive 100 percent inspection by visual, radiographic, and liquid penetrant methods or approved equivalent nondestructive inspection methods.
- ii. Three castings must be statically tested and shown to meet:
 - The strength requirements of § 25.305 at an ultimate load corresponding to a casting factor of 1.25;
 - The deformation requirements of § 25.305 at a load of 1.15 times the limit load.

3) Casting Factor of 1.50 or greater may be used provided that:

- i. Each casting must receive 100 percent inspection by visual, radiographic, and liquid penetrant methods or approved equivalent nondestructive inspection methods.
- ii. One casting must be statically tested and shown to meet:
 - The strength requirements of § 25.305 at an ultimate load corresponding to a casting factor of 1.50;
 - The deformation requirements of § 25.305 at a load of 1.15 times the limit load.

(d) Noncritical castings. For each casting other than critical castings as specified in paragraph (c) of this section, the following apply:

- 1) A Casting Factor of greater than or equal to 1.0 and less than 1.25 may be used provided that the requirements of (c)(1) are met or:
 - i. Castings are procured and manufactured to a specification that guarantees the mechanical properties of the material in the casting and provides for demonstration of these properties by testing of coupons cut from the castings on a sampling basis.
 - ii. Each casting must receive 100 percent inspection by visual, radiographic, and liquid penetrant methods or approved equivalent nondestructive inspection methods.
 - iii. Three sample castings must be statically tested and shown to meet the strength and deformation requirements of § 25.305.

- 2) A Casting Factor of greater than or equal to 1.25 and less than 1.50 may be used provided that

Each casting must receive 100 percent inspection by visual, radiographic, and liquid penetrant methods or approved equivalent nondestructive inspection methods.

- 3) A Casting Factor of greater than or equal to 1.5 and less than 2.0 may be used provided that each casting must receive 100 percent inspection by visual and liquid penetrant methods or approved equivalent nondestructive inspection methods.

- 4) A Casting Factor of 2.0 or greater may be used provided that

Each casting must receive 100 percent visual inspection.

- 5) The percentage of castings inspected by non-visual methods per (d)(2) and (d)(3) may be reduced when an approved quality control procedure is established.

Issued in Washington, DC, on

ARAC General Structures Harmonisation Working Group

Draft AC 25.621

18 May 1999

1. **Purpose:** This advisory circular (AC) sets forth acceptable means of compliance with the provisions of part 25 of the Federal Aviation Regulations (FAR) pertaining to the certification requirements for castings used for structural applications. Guidance information is provided for showing compliance with section 25.621. Other methods of compliance may be acceptable.

2. **Related FAR sections:** 25.619, 25.613, 25.307

3. **Background:** The current 14 CFR part 25 Airworthiness Standards of the Federal Aviation Regulations (FAR) requires classification of structural castings as either critical or non-critical, and depending on classification, specifies inspection requirements, test requirements, and special factors for ultimate strength and deformation

The requirements specified in §25.621 have been in effect for many years, having been carried forward from CAR 4b.307. Prior to that, Civil Aeronautics Manual 04 required a minimum additional ultimate strength factor of 2.0 for castings used in primary structure. The Administrator had the authority to prevent the use of any casting which was not considered acceptable for a given application.

In recent years, casting technology has improved. The use of casting factors for critical applications often results in enough of a weight penalty that other, more expensive processes are necessary.

The European Joint Aviation Requirements (JAR) accept the approved national standards of the participants as an alternative to FAR §25.621. The JAA also have a Notice of Proposed Amendment in process to add a new JAR 25.621, and to include provision for the use of a casting factor of 1.0. Because of the differences in the FAA and JAA requirements and the economic costs associated with those differences, the ARAC General Structures Harmonization Working Group was tasked by the FAA to develop a common requirement. Part of the assigned task was to consider making provision in the rule to allow use of a casting factor of 1.0 for critical castings. The requirement was revised accordingly.

4. **Introduction:** §25.619 includes the requirement to apply a special factor to the factor of safety prescribed in §25.303 for each part of the structure whose strength is subject to appreciable variability because of uncertainties in the manufacturing processes or inspection methods. Since the mechanical properties of a casting depend on the casting design, design values established under §25.613 for one casting may not be applicable to another casting made to the same specification. Thus casting factors are necessary for castings produced by normal techniques and methodologies to ensure the structural integrity of castings in spite of these uncertainties. Another approach is to reduce the uncertainties in the manufacturing process by use of a premium casting process (Reference paragraph 5), which provides a means of using a casting factor of 1.0.

5.0 Premium Castings: This section provides guidance for compliance with 25.621 for using a casting factor greater than or equal to 1.0 and less than 1.25 for critical castings. A premium casting process is capable of producing castings with predictable properties, thus allowing a casting factor of 1.00 to be used for these components. Three major steps: qualification of the process; proof of the product, and monitoring the process are essential in characterizing the premium casting process.

5.1 Definitions

- 5.1.1 *Premium Casting Process:* a casting process that produces castings characterised by a high quality and reliability.
- 5.1.2 *Prolongation:* an integrally cast test bar or test coupon.
- 5.1.3 *Standard Test Casting:* a casting produced specifically for the purpose of qualifying the casting process.

5.2. *General.* The objective of a Premium Casting Process is to consistently produce castings with high quality and reliability. To this end the casting process must be capable of consistently producing castings which have the following list of characteristics:-

- Good dimensional tolerance
- Minimal distortion
- Good surface finish
- No cracks
- No cold shuts
- No laps
- Minimal shrinkage cavities
- No harmful entrapped oxide films
- Minimal porosity
- A high level of metallurgical cleanness
- Good microstructural characteristics
- Minimal residual internal stress
- Consistent mechanical properties

Although the majority of the above can be detected, evaluated and quantified by standard non destructive testing methods or from destructive methods on prolongation or casting cut up tests, a number can not. Thus to ensure an acceptable quality of product the significant and critical process variables must be identified and adequately controlled.

5.3. *Qualification of Casting Process.* To prove a premium casting process, it should be submitted to a qualification programme which is specific to a foundry/material combination.

The qualification programme should establish the following;

- 1) The casting process is capable of producing a consistent quality of product for the specific material specification selected for the intended production component.
- 2) The mechanical properties for the material produced by the process have population coefficients of variation equivalent to that of wrought products of similar composition (i.e. plate, extrusions, bar, and billet). Usage of the population coefficient of variation from forged products is not acceptable.

- 3) The casting process is capable of producing a casting with uniform properties throughout the casting, or if not uniform the variability can be predicted to an acceptable level of accuracy.
- 4) The (initial) material design data for the specified material.
- 5) Clearly defined material and process specifications.

For each material specification, there should be manufactured a series of standard test castings from a number of melts, using the appropriate production procedures of the foundry. The standard test casting produced should undergo a standardised inspection/investigation of nondestructive inspection and cut up testing, to determine the consistency of the casting process.

The standard test casting should be representative of the intended cast product/s, and should expose any limitations of the casting process. In addition, the standard test casting should be large enough to provide mechanical test specimens from various areas, for tensile, and possibly compression, shear, bearing, fatigue, fracture toughness and crack propagation tests. If the production component complies with these requirements it may be used to qualify the process. At least 10 melts should be sampled, with no more than 10 castings produced from each melt. If the material specification requires the components to be heat treated this should be done in no fewer than 10 heat treatment batches consisting of castings from more than one melt. Reduction of qualification tests may be considered if the casting process and/or the casting alloy is already well known for aerospace applications and the relevant data is available.

All standard test castings should be nondestructively inspected 100%, by liquid penetrant and X-ray methods. The specific X-ray standard to be employed is to be determined and the margin by which the standard test castings exceed the minimum required standard recorded. The programme of inspection is to confirm the consistency of the casting process as well as ensuring the stated objectives on surface finish, cracks, cold shuts, laps, shrinkage cavities, and porosity. In addition it is to ensure that the areas from which the mechanical property samples were taken were typical of the casting as a whole with respect to porosity and cleanness.

All standard test castings should be cut up to a standardised methodology to produce the mechanical test specimens detailed above. Principally the tests are to establish the variability within the cast component as well as determining the variability between components from the same melt, and from melt to melt. The data gathered will also be used during latter phases to identify deviations from the limits established in the process qualification and product proving programmes.

All the fracture surfaces generated during the qualification programme must be inspected at least visually for detrimental defects.

As part of the cut up investigation it is usually necessary to take metallographic samples for cleanness determination and microstructural characterisation.

When the process has been qualified, it should not be altered without completing comparability studies and necessary testing of differences (See paragraph 7).

5.4 *Proof of Product.* Subsequent to the qualification of the process, the production castings should be subjected to a production proving programme. Such castings should have at least one prolongation, however large and/or complex castings may require more than one. If a number of castings are produced from a single mould with a single runner system, they may be treated as one single casting.

The production proving programme should establish;

- 1) That the design allowables developed during the process qualification programme are valid for the production casting.
- 2) That the production castings have the same or less than the level of internal defects as the standard test castings produced during qualification.
- 3) That the cast components have a predictable distribution of tensile properties.
- 4) That the prolongation/s is/are representative of the critical area/s of the casting.
- 5) That the prolongation/s consistently reflect quality process, and material properties of the casting.

A number of, at least two, preproduction castings of each part number to be produced should be selected for testing and inspection. All the selected castings should be non destructively inspected as per the qualification programme. One of these castings should be used as a dimensional tolerance test article. The other selected casting/s should be cut up for mechanical property testing and metallographic inspection. The casting/s should be cut up to a standardised programme to yield a number of tensile test specimens and if required, metallographic samples. There should be sufficient cut up tensile specimens to cover all critical (critical with respect to both the casting process and service loading) areas of the casting. All prolongations should be machined to give tensile specimens and subsequently tested. The production castings should be produced to production procedures identical to those used for these preproduction castings.

On initial production a number of castings should undergo a cut up for mechanical property testing and metallographic inspection, similar to that performed for the preproduction casting/s. The cut up procedure used should be standardised, although it may differ from that used for the preproduction casting/s, but as a minimum tensile specimens should be obtained from the most critical areas. For the first 30 castings produced at least 1 casting in 10 should undergo this testing programme. The results from the mechanical property tests should be compared with the results obtained from the prolongations to further substantiate the correlation's between prolongation/s and the critical area/s of the casting. In addition, if the mechanical properties derived from these tests are acceptable, when compared to the property values determined in the qualification programme, the frequency of testing may be reduced. However, if the comparison is found not to be acceptable, the test programme may require extension.

At no point in the production should the castings contain shrinkage cavities, cracks, cold shuts, laps, porosity, entrapped oxide film, or have a poor surface finish, exceeding the acceptance level defined in the technical specifications.

5.5. *Monitoring the Process.* The applicant should employ quality techniques to establish the significant/critical foundry process variables which impact on the quality of the product. The applicant should show that these variables are controlled with positive corrective action throughout production.

During production every casting should be non destructively inspected using the techniques and the acceptance standards employed during the qualification programme. Rejections should be investigated and process corrections made as necessary. Alternative techniques may be employed if the equivalence in the acceptance levels can be demonstrated. In addition tensile tests should be taken from the prolongations on every component produced and the results should comply with limits developed in the process qualification and product proving programme. Also, as previously mentioned, a periodic casting cut up inspection should be undertaken, with the periodicity as agreed during the proof of product programme. Deviations from the limits established in the process qualification and product proving programmes should be investigated and corrective action taken.

5.6 *Modifications to the Casting Design, Material, and Process.* Additional testing may be required when alterations are made to the casting geometry, material, significant/critical process variables, process, or production foundry to verify that the alterations have not significantly changed the castings properties. The verification testing recommended is detailed in the table below.

Modifications					Verification testing		
Case	Geometry	Material	Process	Foundry	Qualification of Process	Proof of Product	Tests per FAR 25.621 (c)(1)
1	?slight [similarity]	none	none	none	not necessary	yes	yes b)
2	slight [similarity]	?yes	none	none	yes a)	yes	yes a) & b)
3	?yes	yes	none	none	yes	yes	yes
4	none	none	none	none	not necessary	yes	yes a)
5	none	none	?yes	none	yes a)	yes	yes a) & b)
6	none	none	none	?yes [second- source]	yes a)	yes	yes a) & b)
<p>a) A programme as per paragraph 4 to qualify a new material, process, foundry combination, as well as static tests as per FAR 25.621(c)(1), may not be necessary if the following exist for the new combination.</p> <ol style="list-style-type: none"> 1) Sufficient data from relevant castings to show that the process is capable of producing a consistent quality of product, and that the quality is comparable or better than the old combination. 2) Sufficient data from relevant castings to establish that the mechanical properties of the castings produced from the new combination have a similar or better statistical distribution than the old combination. 3) Clearly defined material and process specifications. <p>b) The casting may be re-qualified by testing partial static test samples (with larger castings re-qualification could be undertaken by static test of the casting's critical region only), this should be approved.</p>							

6.0 General guidance for use of casting factors

6.1 For the analysis or testing required by 25.307, the ultimate load level must include limit load times the required factor of safety and the casting factor of 25.621. The testing required under 25.621 may be used in showing compliance with 25.305 and 25.307.

6.2 The inspection methods prescribed by 25.621(c) and (d) for all production castings must be such that 100% of the castings are inspected by visual and liquid penetrant techniques with total coverage of the casting. With regard to the required radiographic inspection each production casting must be inspected by this technique, however due to the practicalities of this technique the inspection may be limited to the structurally significant areas of the castings, when approved by the Administrator.

6.3 With the establishment of consistent production, it is possible to reduce the inspection frequency of the non-visual inspections required by the rule for non-critical castings with the approval of the administrator. This is usually accomplished by an approved quality control procedure incorporating a sampling plan.

6.4 The static test specimen(s) should be selected on the basis of the foundry quality control inspections in conjunction with those prescribed in §25.621(c) and (d). An attempt should be made to select the worst casting(s) from the first batch produced to the production standard.

FAA Action: Placed on the AVS “Do By Other Means” list, dated June 14, 2005.